

Green River Lake, KY – Sustainable River Project

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ABSTRACT

In July 2002 the U.S. Army Corps of Engineers (COE) and The Nature Conservancy (TNC) formed a partnership to restore and preserve rivers across the United States. This agreement, known as the Sustainable Rivers Project, had its beginnings with a TNC and COE partnership to improve habitat along the Green River below Green River Lake.

The Green River area below Green River Lake is considered to be one of the most diverse rivers for fish and mussel species in the United States. The partnership led to successful projects within that watershed area that would improve the riparian and ecological habitat while still maintaining the COE flood control mission in the basin. Modifications to the operation of Green River Dam are currently being evaluated through a three year trial period to assess the impacts that were identified as potential ecological improvements in the downstream target areas.

Currently thirteen other Corps of Engineers Dams sites have been identified as candidates under this Sustainable Rivers Project agreement. These sites are located in the states of Arkansas, Arizona, New Hampshire, Pennsylvania, North Carolina and Washington. Other dams may be identified in the future.

Background

In the fall of 1998 representatives of The Nature Conservancy (TNC) met with representatives of the Louisville District, U. S. Army Corps of Engineers (COE) to discuss opportunities for the two organizations to develop a beneficial working relationship in the Green River Area of Kentucky. The primary focus of the partnership was to identify and understand environmental problems within the Green River Bioreserve area and forge partnerships among various interested parties to implement solutions.

The Green River Bioreserve is a 1350 square mile area within the Green River Basin and extends 110 river miles from the tailwater of the COE Green River Lake to downstream of the Mammoth Cave National Park at old Lock and Dam 6 on the Green River at Brownsville, KY. The Green River Bioreserve is among the most significant aquatic systems in the United States and has TNC's highest biodiversity rating. The area includes over 151 species of fish and 71 species of fresh water mussels. There are 35 aquatic species in the area that are considered imperiled. To implement strategies throughout the watershed to protect and restore the ecosystem functions and rare plants, animals, and communities that are indigenous to this aquatic area was a key goal of this partnership.

One of the key TNC strategies is to restore the natural hydrologic variability in flow and temperature in watersheds. This objective cannot be achieved within the bioreserve area without the full cooperation and support of the Louisville District

COE in implementing a modified operation of their Green River Lake. The investigation of modifying the operational characteristics of the lake is the main topic of his article.

Green River Lake Operation

Green River Lake is a multipurpose lake providing flood control, water supply, water quality and recreational benefits to the Green River Basin and Lower Ohio River Basin. The lake was authorized by the Flood Control Act of 1938 and began operation in February 1969. The drainage area above the dam is 682 square miles. The dam was constructed of earth and fill material and is controlled by a gated concrete control structure and conduit system located at the base of the dam. There is minor capability for release of water from different levels of the impounded pool.

The lake maintains a pool elevation of at least elevation 664 during the winter months. Around mid-March the lake stores spring runoff and to build an 11 ft conservation storage pool. This pool allows the lake to maintain a desired minimum low flow below the dam during normally low flow periods of the year and provides a recreation pool through the summer and early fall. It is a goal for the lake to reach the conservation pool (a.k.a. summer pool) by mid-April. At the end of the recreation season the lake begins releasing from the conservation storage in order to return to the normal pool elevation of 664 by early December. This lake drawdown begins slowly in mid-September and increases in mid-October.

Throughout the year the lake is operated to store flood waters when river levels below the dam are above target stages and release the accumulated flood storage as fast as possible when levels below recede below their target stages. The lake was designed to release at maximum outflow of 8000 cfs during non-crop periods and 5300 cfs during crop periods. Following the dam's early operational years downstream property owners slowly encroached on the stream to a point where maximum outflows were reduced to about 6000 cfs during non-crop periods and 4400 cfs during crop periods.

During non flood periods, the lake is operated to maintain elevation near the guide curve by regulating outflow and to release at least a minimum of 50 cfs. The lake also follows a tailwater temperature guide curve that was developed in the early 1970s in cooperation with The Fish and Wildlife Service.

One of TNC's major concerns involves outflows from the lake during periods that are considered atypical of the natural Green River temperature and flow regimes. This generally occurs during late spring and summer periods of high outflow releases and during late fall periods of release to return to normal pool levels. It is necessary to release these high release rates from the low level conduit located at the base of the dam because of inadequate capacity of the multilevel outlet structure. Water temperatures at this low level are colder than upper lake levels during times of lake stratification. Outflow from the multilevel outlet system has a capacity of only 340 cfs. The question posed by TNC was does adequate flexibility exist within the operation of Green River Lake to accomplish a more natural flow and temperature

regime while still providing an acceptable level of flood control and recreation benefits.

The COE agreed that during certain times of the year high/low level/cold water releases are necessary to maintain the current operational objectives of the project. The COE also agreed that some flexibility may exist in these objectives which would allow for a more natural regimen of reservoir release. The COE offered to consider a modified plan of operation on a three year trial basis, provided the proposal maintained acceptable levels of current benefits (especially flood control and recreation) and provided TNC collects data downstream to qualify/quantify the benefits served by the modification.

In 2000 TNC began collecting base line data in the Green River Bioreserve area through the installation of 5 temperature monitors on the main stem Green River and 3 monitors on significant downstream tributaries. The U. S. Geological Survey (USGS) through contract with the COE also collected and transmitted real time temperature data at 4 other gaged sites in the study area. TNC has also contracted with Southern Illinois University to conduct invertebrate monitoring and fish monitoring at selected locations in the bioreserve area.

Alternatives

There were four basic aspects considered for modifying project operation: change in pool levels; change in operating releases; change in guide curve; and change in downstream control objectives. Since changing downstream control objectives could compromise the COE flood control purpose, no consideration was given to modification of these levels. Likewise, since recreational facilities at the project were designed for a seasonal pool level of 675, modification of this level would incur significant cost and create social unrest. Thus no consideration was given to a change in seasonal pool level.

Modifications considered therefore for analysis consisted of change in operating releases; change in winter pool level; and, change in guide curve. Over twenty plans of operation were considered. Some of those plans performed exceptionally well with regard to TNC objectives but failed with regard to COE objectives. For example, a delay of one month in the start of filling to summer pool can have a significant positive influence on the reduction of high/low level/cold water releases in May and a positive influence on flood control; unfortunately, it has an associated significant adverse impact on attainment of desired recreation levels. Plans which produced unreasonable negative impacts on current benefits were not considered further.

Plans Considered

Using the current operating plan as a base of comparison, eight modified operating plans were developed and analyzed in detail with regard to flood control, recreation, water quality, water supply, and reduction of high/cold water releases in May/June and September/October. These eight plans are:

- 1) The current operation plan with a higher non-Crop release of 8000 cfs as was originally designed.
- 2) The current plan with the higher non-Crop release and delaying the drawdown to November.
- 3) The current plan with the higher non-Crop releases, the delayed drawdown, and delaying the fill to April.
- 4) A 668 winter pool with higher non-crop releases, a normal drawdown, and a delayed fill.
- 5) A 668 winter pool with higher non-crop releases, a delayed drawdown and a delayed fill.
- 6) A normal winter pool with higher non-crop releases, a delayed drawdown, and a variable fill that would begin as the current operation but not reach summer pool until mid-May.
- 7) A normal winter pool with higher non-crop releases, the variable fill and a delayed variable drawdown.
- 8) A 668 winter pool with higher non-crop releases, a delayed varied drawdown, and a delayed variable fill.

The naturally variable drawdown rate was a key proposed change in operation. One of the concerns raised by TNC regarding fall drawdown was the maintenance of a somewhat constant outflow over a prolonged period of time. For the modified plans a variable drawdown rate was considered that would simulate a natural hydrograph for the area.

Evaluation Methods

Each of the plans was first evaluated using the Louisville District COE “Reservoir Regulation Program” (RRP). This program is a sequential model that utilizes project inflow and downstream control station data in combination with the schedule of regulation and release constraints to develop a set of operated pool levels and outflows. The period analyzed was water year’s (WY’s) 1940-1990 or 51 years of record. A portion of this period WY’s 1940-1968 was prior to the existence of Green River Lake and is therefore a hypothetical operation. The portion of record

from WY's 1969-1990 reflects actual project operation and was used to determine the quality of fit of the operational model. The operated outflows and pool levels resulting from the schedules analyzed were then applied using a suite of programs associated with the RRP to develop monthly outflows and reservoir pool level duration data, reservoir peak pool level and frequency data, and downstream reservoir modification data. Comparison of targeted parameters developed in these analyses forms the basis for the initial screening of the modified operating impacts.

Once this phase was complete, outflow output data from the RRP was reformatted for application in the TNC program "Indicators of Hydrologic Alteration" (IHA). The IHA program permits evaluation of 33 statistical parameters (pre and post project) to interpret the impacts of reservoir operation on the natural flow regime. For the purpose of this study, the 51 years of inflow data was considered as pre-project or unregulated data and the outflow data for each of the plans considered was used as the post-project or regulated data. Using this approach the relative merit of each modified plan of operation was evaluated.

Reduction of Spring (May/June) Cold Water Releases

To reduce the cold water releases in May and June, the period when reservoir releases can be controlled using the multilevel outlet system must be increased. For Green River Lake, this outlet system is limited to about 350 cfs.

None of the plans considered had significant impact on the reduction of June cold water releases. Since all plans are scheduled and operated to attain summer pool by at least Memorial Day, most low level/cold water releases in June are associated with evacuation of storage from June flooding after summer pool has been attained. The only means to reduce this occurrence would be to further delay the filling to summer pool; this would not be acceptable to the COE. Unless there is an increase in multilevel release capability at the project, June cold water releases will continue at the same frequency.

Reduction of May cold water releases is a different matter. Plans with delayed filling have a significant impact on the reducing the occurrence of these events. This reduction could also provide some limited agricultural benefit, since there is an associated reduction in duration of high releases in the late spring.

Increasing the peak outflow ability during the non-crop periods also reduces the duration of cold water discharges during the spring. This increase in outflow to design conditions was accomplished by two programs that were available through two partnering agencies in this effort. TNC through its nationally known program identifies areas that would best be suited for natural habitat rather than developed for uses that would have negative impact on the environment. Within the Green River Bioreserve area the COE identified areas downstream of the projects that directly impacted on are ability to release high outflows. TNC was able to obtain those

properties and have them established as riparian buffer zones beneficial to the habitat for the area.

In addition to TNC, the Department of Agriculture through their Crop Replacement and Enhancement Program (CREP) was able to offer incentives to local agriculture interests to set aside areas along the river corridor as riparian habitat. These areas will be taken out of crop production and planted with native trees and plants in order to create beneficial habitat areas near the stream.

Reduction of Fall (September/October) Cold Water Releases

As discussed in the previous section, Green River Lake is limited to an outflow of 350 cfs when operated for downstream temperature control through the multi-level outlet system. The current operating plan calls for discharges in excess of this capacity beginning in mid-October. October temperature objective can be maintained; and, bring the duration of flow considerably closer to that which would be experienced in a natural condition.

Two dates for initiation of significant drawdown were investigated, 1 November and 15 November. The only real difference in these alternatives is that if it is imperative to reach winter pool by 1 December the latter plan requires releases that are twice as high. In either case, the releases are well within the maximum crop season guidelines. Inspection of historical lake temperature profiles shows that though total destratification doesn't routinely occur until mid-November, there is adequate thermal destratification by 1 November to meet tailwater temperature objectives with low level or main gate discharges. The decision of when to initiate the significant portion of the drawdown should be dictated by the conditions existing for each operational year and the capability to smoothly transition to a low level discharge which meets the temperature guidance.

IHA

The IHA characterizes the natural range of variability in key hydrologic parameters and the degree to which these parameters have been altered. As discussed previously, for this study the natural inflows for Green River Lake for the study period were used as the pre-impact condition and the outflows associated with each plan of operation were used as the post-impact condition. As would be expected the impacts of storing water during the spring and then releasing this water during the fall has an impact on the Coefficient of Variation and the Hydrologic Alteration parameters. With the lake being a flood control lake, the maximum release for the project is far less than the inflows routinely experienced during the winter months, the IHA parameters reflect the COE store and release policy during this portion of the flood season. Rates of rise and fall for the current plan and all modified plans considered correlate well with those experienced in the natural flow regime. Change in release policy currently used in the operation of Green River Lake is compatible with the variations expected in the natural regime.

Recommendation

Plan 8 was chosen as the modified operation plan. The higher non-crop season releases provide additional flexibility in project operation and reduce the peak pool levels in the project. Recreational benefits and pool attainment are at least equivalent to the current plan with some possible increase due to the extended period of October utilization.

From a flood control perspective peak pool levels are reduced significantly versus the current operating plan. There will be equivalent downstream flood control benefits as the existing plan of operation. Recreationally this plan reduces the days in the JJAS zone of desired levels by 4.5%, but the recreation season is extended through October due to the later drawdown. Also, some recreational benefit may be derived from the higher winter pool. This plan also produces a greater tendency for stable to slowly rising pool levels during the traditional period of spawn. May cold water releases associated with this operation are reduced by over 15%; and October cold water releases are reduced by 41.8%.

Delaying the drawdown to November also enable the lake to make its higher releases after the lake pool has destratified. Destratification usually occurs in early to mid-November. Varying the outflow pattern during this drawdown period to simulate natural hydrograph conditions also provides benefits for the natural variability of the downstream flow regime.

Water temperature data collected below the dam and research of past records showed that the tailwater guide curve should be modified to more closely simulate a natural water temperature regime downstream of the dam. This new tailwater temperature guide curve will also be evaluated for the change in operation plan.

Conclusion

The collaboration between the Corps of Engineers and The Nature Conservancy in the Green River area has demonstrated the benefits that can be obtained from this valuable partnership. Each side respected the others' mission and goals and from this identified common goals to each. The partnership was able to draw in other interested parties whom will benefit from not only the enhancement to the environment but also gain in the understanding of the environment and the impacts associated with processes within the area.

The benefits and impacts will be analyzed for three years using the modified lake operation plan. From this everyone will gain more than if each acted alone. The Green River Lake operational modifications will provide improved ecological management for the environment while continuing to provide its authorized benefits to the Basin.